Circomod Policy Brief 4:

Circular economy policy for buildings and transport in Europe

CIRCOMOD is an EU research project that develops integrated models, data and decision-support tools to assess how circular economy strategies can reduce greenhouse gas (GHG) emissions and material use at scale.

Executive summary

This brief is part of a series produced by the CIRCOMOD project, which models the contribution of circular economy strategies to climate mitigation across sectors and regions. The CIRCOMOD project organises circular economy action into three archetypes: **narrowing strategies**, which reduce demand for materials and services at source; **slowing strategies**, which extend the useful life of products and materials already in circulation; and **closing strategies**, which keep materials in use at end of life through recycling and recovery. This brief draws on modelling results from CIRCOMOD Deliverable 6.1 and 6.2.

This brief is addressed to EC DG CLIMA, DG ENER, and DG MOVE, and to member state ministries with responsibility for buildings and transport policy.

KEY MESSAGES

1. Circular economy strategies can cut EU material demand in buildings by 30 to 50% and in vehicles by 39 to 74% by 2050.

2. Narrowing dominates both sectors. Lower per-capita floorspace and reduced private vehicle use, supported by a wider mobility mix, deliver the largest and fastest emission reductions – and European service levels make this feasible in the short-term.

3. Slow strategy design is decisive to achieve decarbonisation potential. Vehicle lifetime extension delays fleet electrification and can increase transport emissions; building lifetime extension reduces embodied carbon only where the building can also be brought to high thermal performance.

Why now

The EU's building stock turns over slowly. Mean lifetimes of 60 to 120 years for residential buildings mean that construction decisions taken today remain embedded in the stock until 2080 or beyond. In transport, fleet composition choices made in the next decade lock in cumulative Scope 1 emissions through the 2040s. The Energy Performance of Buildings Directive (EPBD) recast, Ecodesign for Sustainable Products Regulation (ESPR) delegated acts rolling out between 2026 and 2030, the new End-of-Life Vehicles (ELV) Regulation, the EU taxonomy revision, and the EU's second Emissions Trading System (ETS2) implementation from 2027 each create intervention windows that will not recur on a short timescale.

European material stock embedded in transport and housing infrastructure is high, which makes narrowing a feasible strategy. On transport, most major European cities have existing rail, metro, and tram networks that could absorb significantly more demand with targeted investment. The wider mobility mix is expanding rapidly where enabling conditions exist: cyclists now outnumber motorists in central Paris, and nearly half of all commuter journeys in Copenhagen are made by bike. These outcomes followed deliberate infrastructure investment over one to two decades, and the pattern is spreading.

On buildings, the housing shortage documented across European cities makes clear that expanding supply is a precondition for affordability. Average house prices in the EU rose 60% between 2015 and 2025, and rents consume 40% or more of average salaries in many markets. How this supply gap is closed matters for narrowing: settlement patterns that lock in land consumption and car dependency make demand-side strategies harder to achieve later.

A structural feature of European housing sits alongside this supply challenge and is frequently overlooked. Eurostat data show that a third of the EU population lived in under-occupied homes in 2024, a share broadly stable since 2010. Close to half of people aged 65 or over live in under-occupied dwellings, compared with less than a third of working-age adults. This reflects a mismatch between the size of existing urban and suburban family housing stock and the smaller households that now occupy it, not an oversupply of homes in the wrong places. Survey evidence identifies the lack of suitable smaller homes and high transaction costs, particularly transfer taxes, as the principal barriers to downsizing. These barriers are addressable at member state level, and some are already moving to reform them (see Policy implications). Supply expansion and better use of existing stock are complements, not alternatives.

Transport decarbonisation cannot be achieved through technology transitions alone: while electrification is essential for reducing direct emissions, circular economy strategies, particularly those targeting service demand, are critical for addressing the full emission profile of transport systems. The cross-sectoral demand-side case is developed in CIRCOMOD Policy Brief No. 2.

What the models show

Buildings

Narrowing delivers the largest and fastest material savings. IMAGE and RECC-CE project 30 to 50% lower material demand under narrow scenarios compared to the no-CE baseline by 2050, driven by reductions in per-capita floorspace and more intensive use of existing stock.

Slow strategies contribute little in the 2030 to 2050 window, because most existing stock has not yet reached end of life. They become increasingly effective later in the century as building retirements are delayed or avoided. Extending the lifetime of buildings with poor thermal envelopes imposes a use-phase energy penalty by delaying replacement with lower-energy stock.

Close strategies add little in the buildings analysis, with cumulative emissions reductions below 1%, because baseline recycling rates for metals such as steel are already high and rise further without additional CE measures. In the modelling, the baseline steel end-of-life recycling rate in buildings is around 83%, rising to about 92% under close scenarios, so construction steel is near its technical recycling potential. For glass, plastics, and aggregates, close strategies do deliver meaningful shifts from virgin to secondary supply. High recycling rates already achievable demonstrate what is technically possible and provide a direct evidence base for setting ambitious targets in building standards and procurement rules in regions where rates remain far lower.

Transport

Narrowing dominates more clearly here than in buildings. EU car stocks fall by 14 to 53% under narrow scenarios by 2050 across models, driven by reductions in per-capita travel demand, modal shift, and downsizing toward smaller vehicles. For Europe specifically, narrow strategies can reverse baseline transport demand growth altogether: baseline activity grows 13 to 28% by 2050 across models, and circular economy scenarios can reverse this increase. Together with downsizing and lightweighting, these shifts cut vehicle material demand by 39 to 74% by 2050. Note on scope: the CIRCOMOD scenarios model modal shift explicitly to bus and rail, combined with activity reduction and vehicle downsizing. Cycling, walking, e-bikes, and shared mobility are not modelled explicitly but are reflected in the aggregate activity targets the scenarios assume. References to the "wider mobility mix" cover both the modelled and unmodelled components.

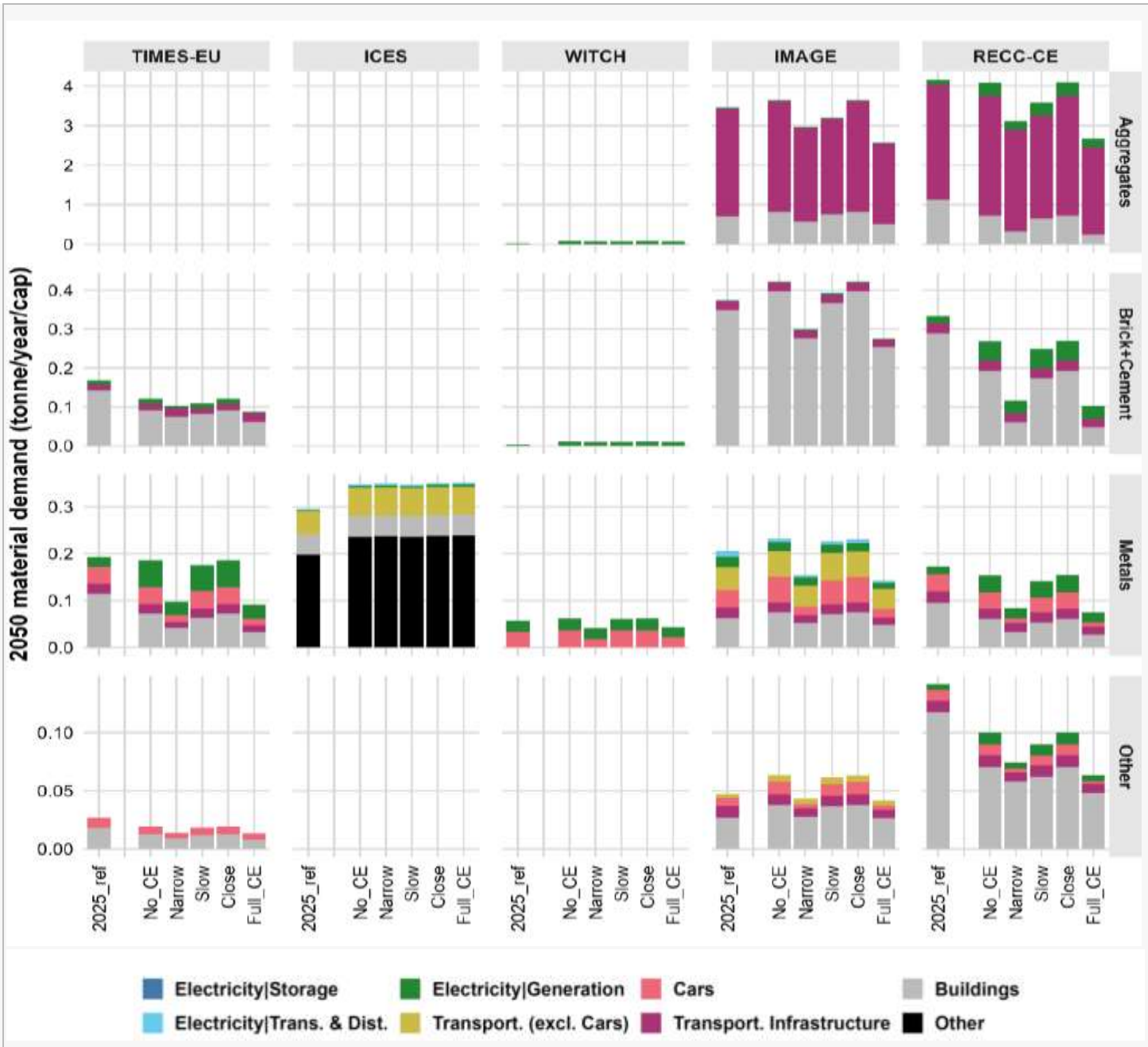

Figure 1: Projected EU final material demand per capita in 2050 by scenario. 2025_reference represents values for the No_CE scenario and the year 2025. Aggregates include Aggregates, Stone and Asphalt, Metals include Aluminium, Copper and Steel, Other includes Plastics, Glass and Wood. IMAGE and WITCH do not provide results for cement and aggregates in concrete, but only concrete. Values for concrete were split into cement and concrete aggregates (0.12|0.88 concrete mass) and added to "Brick and Cement" and "Aggregates", respectively. Empty plots: No coverage in respective model. 'Transport. (excl. Cars)' = All transportation vehicles (road, rail, air, water), without cars; 'Transport. Infrastructure' = Transportation infrastructure. Source: Adapted from CIRCOMOD D6.1, Figure 15.*

CE and climate policy are strongly complementary. Climate policy reduces Scope 1 emissions through electrification; narrowing reduces Scope 1, 2, and 3 by shrinking the fleet and the material flows required to build and replace it. Combined scenarios cut material-related Scope 3 emissions by 56 to 84% across models. One striking secondary finding: with deep grid decarbonisation, aluminium Scope 3 emissions turn negative in TIMES-EU and RECC-CE because the upstream electricity used for smelting is net carbon-negative.

The slow strategy finding is the sharpest policy-relevant result in the transport chapter. GEM-E3 and TIMES-EU both show that extending vehicle lifetimes increases transport emissions relative to baseline by slowing the replacement of internal combustion engine vehicles with electric ones. Material savings from keeping vehicles in service longer cannot offset the additional Scope 1 emissions from delayed electrification.

Freight stands apart. Road freight demand grows in every scenario, CE levers for aviation and shipping are weak, and no model projects an absolute reduction in freight emissions from CE strategies alone.

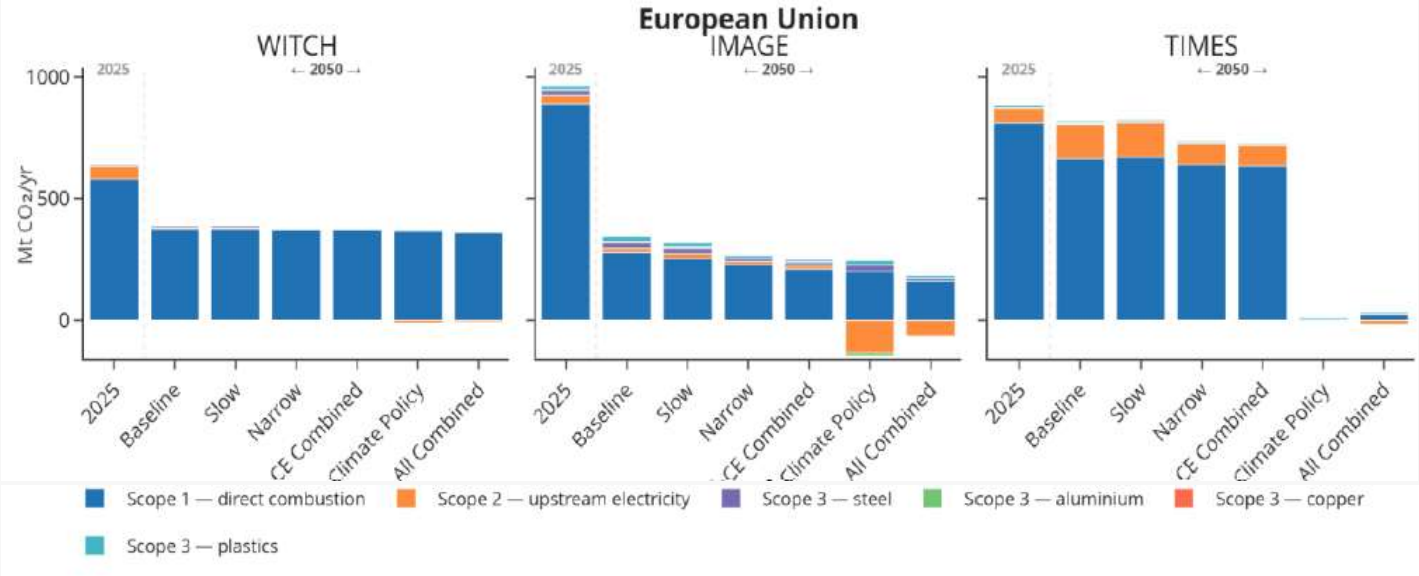

Figure 2: Transport CO_2 emissions by model, region and scenario. Scopes 1, 2, 3, for 2025 and per scenario results for 2050. The top figure excludes RECC as RECC does not calculate Scope 1 and 2 emissions. Scope 1 follows GHG protocol demand-side accounting conventions, attributing direct fossil and biofuel combustion to the transport end-use sector. Scope 2 includes emissions from electricity use in transport. Scope 3 includes production emissions of four included materials (steel, aluminium, copper, plastics). For plastics, 80% of energy use is assumed to be for feedstock of which 50% is assumed to be released and therefore included here. The remaining 20% process emissions are also included fully. Note that for TIMES, the scope 3 emissions are cars only and WITCH reports for cars and trucks.

Source: Adapted from CIRCOMOD D6.1, Figure 46

Policy implications

Several implications follow from the modelling, each pointing to a design choice in existing or forthcoming EU instruments.

Narrowing requires enabling conditions. Narrow scenario savings depend on structural changes that price signals alone do not deliver. In transport, the wider mobility mix requires physical infrastructure: public transport investment, cycling networks, and integrated shared mobility services. In buildings, the barriers to efficient use of existing stock are fiscal and planning-related – several member states are now testing related instruments. The Netherlands targets to build at least 290,000 homes suitable for older people by 2030 to enable downsizing and free up family homes. Denmark's 2017 property tax reform (effective from 2024) linked tax rates to market values, creating stronger incentives for efficient use of housing stock.

Building energy performance regulation should capture material efficiency, rather than only operational energy efficiency. Whole-life carbon reporting – now entering EU regulation through the Energy Performance of Buildings Directive (EPBD) 2024 recast, applying to all new buildings from 2030 – is one step in this direction. As currently designed, however, it does not directly incentivise reducing material demand per unit of floorspace. Lightweighting, improved structural design, and material substitution emerge as significant levers in the modelling; capturing them in practice requires Global Warming Potential (GWP) limit values, of the kind France's RE2020 and Denmark's building code already apply.

Slow strategies need conditionality built in. Building lifetime extension, renovation, and repurposing reduce embodied emissions and defer the material flows associated with building demolition. Where buildings have poor thermal envelopes, the same strategies defer the operational carbon savings of better stock. Policies that support deep retrofit to bring buildings to near-zero operational performance can avoid locking in emissions. In transport, the equivalent argument is sharper: vehicle lifetime extension retains ICE vehicles in service beyond the point they would otherwise be replaced. The EU's ELV Regulation and the CO_2 Emission Performance Standards for cars and vans (Regulation 2019/631 as amended) are examples of instruments already positioned to carry such conditionality.

Rebound effects are a design constraint, not an afterthought. CGE models consistently show that material savings freed up through CE measures shift spending into other emissions-intensive sectors. The magnitude varies across models and CIRCOMOD does not resolve the uncertainty, but the directional finding is robust. Resource taxation, consumption standards, and the ETS are the available guardrail instruments. The modelling adds a precise argument for integrating them with CE policy, rather than treating them as separate problems. For road transport specifically, ETS2 will introduce a cross-cutting price signal on emissions-intensive travel from 2027; member state vehicle taxation reform represents a complementary lever, for which the Commission can provide a reference framework through the EU taxonomy and the Fit for 55 legislative architecture.

Sequencing across strategies also matters for capturing the modelled potential: narrowing first, extending or slowing where assets are already low-carbon, and closing loops where primary production displacement remains achievable, captures more of the combined savings than treating the three as independent tracks.

Recommendations

These recommendations are addressed to EC DG CLIMA, DG ENER, and DG MOVE, and to member state ministries with buildings and transport portfolios.

Extend the EPBD's whole-life carbon framework to cover material efficiency, requiring that new buildings demonstrate minimisation of material demand per unit of floorspace alongside low-carbon material use. The EPBD 2024 recast (Article 7) requires whole-life carbon calculation for new buildings from 2030, and national GWP roadmaps are due by 1 January 2027. France's RE2020 and Denmark's building code GWP limits provide existing member state reference points. The EU taxonomy's sustainable construction criteria and EU Green Public Procurement guidance for construction should require demonstration that floorspace and material demand have been minimised relative to service need, not only that materials are low-carbon or recycled.

Differentiate durability and repairability requirements by asset carbon intensity, drawing on the instruments already in development for buildings and vehicles respectively. For building components and systems, ESPR delegated acts provide the framework for durability and repairability requirements differentiated by operational performance. For vehicles, which sit outside ESPR scope under Article 1(2), ELV Regulation implementing acts should differentiate design lifetime expectations by powertrain type. The CO_2 Emission Performance Standards for cars and vans (Regulation 2019/631 as amended) establish the electrification trajectory reference against which conditional durability requirements should be calibrated.

Extend national building renovation plans and transport contributions to national climate plans to include CE demand-reduction targets and monitoring frameworks alongside energy performance and electrification metrics. EPBD national renovation plans were submitted in draft by member states in December 2025; subsequent EPBD review cycles provide the mechanism for incorporating CE demand-reduction targets alongside energy performance requirements. Transport NCPs under the EU Climate Law provide the equivalent framework for modal shift and vehicle stock reduction targets. The European Commission's New European Bauhaus initiative (2021) offers an existing Commission framework linking sustainability, quality, and affordability criteria in the built environment. CE mitigation operates primarily through Scope 3, which electrification does not reach.

Classify modal shift and active travel infrastructure as climate mitigation investment within EU funding frameworks, and address freight transport directly through existing pricing and modal shift instruments. EU Structural and Cohesion Funds eligibility criteria provide the mechanism for prioritising public transport, cycling, and intermodal investment. ETS2, covering road transport from 2027, represents the EU-level cross-cutting pricing mechanism for emissions-intensive passenger travel; the interaction between ETS2 price signals and CE demand reduction is an open policy design question for the Commission. For freight, where CE levers are weakest, the TEN-T Regulation (2024/1679), the revision of the Combined Transport Directive, and the Eurovignette Directive together provide the instruments for modal shift to rail, load factor optimisation, and pricing of road freight externalities.

Remove fiscal and planning barriers to efficient use of existing building stock and redirect development toward brownfield sites, using instruments at both EU and member state level. The EU Affordable Housing Initiative (Commission 2024) provides the primary EU-level framing for affordable supply expansion and brownfield priority. The EU Urban Agenda and cohesion fund eligibility criteria for brownfield regeneration offer complementary mechanisms. The European Commission's New European Bauhaus initiative (2021) provides design quality and sustainability criteria applicable to new supply. At member state level, transfer tax reform is the principal fiscal barrier to downsizing and falls within national competence.

Caveats

Model results diverge significantly. The emission reduction potential of CE strategies in the EU ranges from around 1% of cumulative 2025 to 2050 emissions (WITCH) to around 10% (TIMES-EU) under narrow scenarios. Demand-driven physical models (IMAGE, TIMES-EU, RECC-CE) project larger reductions than CGE models (GEM-E3, ICES, WITCH), which

incorporate economy-wide spending shifts that can partially offset material savings. The physical models provide a ceiling on technical potential; the economic models provide a more conservative estimate reflecting behavioural and market responses. Policy should aim toward the technical ceiling while putting in place the guardrails needed to prevent rebound. Strategy effects also do not simply add: combining narrow, slow, and close produces smaller total savings than the sum of each in isolation, and in transport the slow strategy's ICE lock-in partially offsets narrow's gains in models that capture fleet dynamics. The individual-strategy figures in this brief illustrate each lever's direction and scale; they are not separately additive.

The scenarios represent technical feasibility, not political feasibility. Inputs such as a 25% reduction in per-capita travel demand (varying across region) and floorspace reductions toward 36 m² per capita are calibrated to what the research literature identifies as achievable. The gap to current political conditions is a policy design problem, not a reason to revise the targets downward.

Freight, aviation, and shipping are not resolved. CE levers for these modes are weak and demand grows in every scenario. The buildings and passenger transport findings here are partial, not comprehensive, accounts of what CE can contribute to EU transport decarbonisation.

Lightweighting, building passports, and modern methods of construction are not directly modelled. They appear in this brief as enabling instruments for realising the material efficiency potential the narrow scenarios project, inferred from scenario logic rather than model output.

Further reading

CIRCOMOD Deliverable 6.1, Chapters 4, 5, and 6 (EU analysis, Buildings, Transport): the primary source for all quantitative findings in this brief.

CIRCOMOD Deliverable 3.4: scenario design and CE strategy targets underpinning the modelling.

CIRCOMOD Policy Brief 1: Tools and methods for policymakers and industry

CIRCOMOD Policy Brief 2: Circular economy as a complementary tool for climate change mitigation.

CIRCOMOD Policy Brief 3: Circular economy, material demand, and the macroeconomics of decarbonisation

European Commission, Energy Performance of Buildings Directive (EU) 2024/1275 and the December 2025 delegated regulation establishing a common GWP calculation methodology.

European Environment Agency (2022), Modelling the Renovation of Buildings in Europe from a Circular Economy and Climate Perspective (Metabolic report for EEA): complementary EU buildings analysis.

Hertwich et al. (2019), Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future, International Resource Panel: foundational framing for material efficiency as a climate tool.

Pauliuk et al. (2024), scenario analysis of CE and climate change mitigation in the global building sector: underpins the buildings chapter methodology.

About CIRCOMOD

CIRCOMOD is an EU research initiative that develops integrated models to quantify how circular economy strategies – such as material efficiency, product lifetime extension, reuse, and high-quality recycling – can reduce greenhouse gas emissions and resource use at scale.

By combining detailed data on material flows, real-world technologies, and economic dynamics, the project enables a system-wide assessment of the impacts of circular strategies across sectors and regions. The project ran from 2022 to 2026.

Further information

CIRCOMOD data hub:
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